

Smith (G. L.)
Franklin Baker,
March 14, 1861.

box 14.

DR. J. L. SMITH,

ON THE

GUERNSEY COUNTY (O.) METEORITES.

M E T E O R I T E S.

PROF. J. LAWRENCE SMITH would be pleased if those parties who may discover meteoric masses, or hear of the fall of any, would communicate with him on the subject, as he has been for several years engaged in investigating their physical and chemical characteristics, with a view to elucidate as far as possible the phenomena connected with their origin and fall. Some of his conclusions have already been published in the American Journal of Science for 1855, 1860, and 1861.

Prof. SMITH would exchange with parties possessing meteorites. for others they may not have ; among those in his possession for exchange are the following :

Claiborne, Tenn., Iron, 55 lbs., for description see American Jour. of Science, 1855.				
Robertson, Tenn.,	do. 37 lbs.,	do.	do.	1861.
Nelson, Ky.,	do. 161 lbs.,	do.	do.	1860.
Oldham, Ky.,	do. 112 lbs.,	do.	do.	1861.
Madison, N. C.,	do. 9 lbs.,	do.	do.	1860.
Putnam, Ga.,	do. 77 lbs.,	do.	do.	1854.
Guernsey, Ohio,	Stones, fell 1860,	do.	do.	1861.
Harrison, Ind.,	do. fell 1859,	do.	do.	1860.
Lincoln, Tenn.,	do. fell 1855,	do.	do.	1861.
Atacama, South America, Iron.				

Of all the above, but the last three, small and large specimeps can be furnished ; of the last three there are only a few small specimens for exchange. Others can be obtained from Prof. SMITH, not enumerated in this list.

THE

GUERNSEY COUNTY (OHIO) METEORITES:

A

COMPLETE ACCOUNT OF THE PHENOMENA ATTENDING
THEIR FALL,

WITH A

CHEMICAL ANALYSIS OF THEM.

BY

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NEW HAVEN:

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ON THE GUERNSEY COUNTY (OHIO) METEORITES.

AGREEABLY to the promise made in the July number of this Journal, I propose giving, as far as possible, a complete account of the remarkable fall of meteoric stones that occurred in the month of May in the eastern part of the State of Ohio.

I have thought proper to call them the *Guernsey County Meteorites*; since we are commonly in the habit of distinguishing the meteorites found in this country, by the name of the county in which they fell or were found. All but one of the great number of meteoric stones that fell on this occasion, were found in Guernsey county and that exceptional specimen fell in Muskingum on the edge of Guernsey county.

Although the public have been notified of this phenomenon by various observers, especially by those who gave their observations in the July number of this Journal; yet, as this paper was nearly completed at the time, and is believed to embrace a full description, it is as well to present it to the public as it is; combining all the particulars of this fall of meteorites, the most remarkable ever observed in this country, and equal to, if not surpassing the famous fall at l'Aigle in France, with which it has many points of interest in common, that will be stated in the course of this paper.

My attention was first directed to this occurrence, by a short notice of it in a newspaper, as being an earthquake that had occurred in eastern Ohio, accompanied with a shower of stones. Suspecting the true nature of the phenomenon, I immediately visited the spot, where it was said to have occurred and collected the statements of those persons who had witnessed the fall. It was ascertained that on Tuesday, May 1st, 1860, remarkable phenomena transpired in the heavens, of which the following are accounts given by different observers, men of intelligence and observation.

Mr. McClenahan states that at Cambridge in Guernsey county Ohio, (lat. $40^{\circ} 4'$ long. $81^{\circ} 35'$) about twenty minutes before one o'clock, P. M., three or four distinct explosions were heard, like the firing of heavy cannon, with an interval of a second or two between each report. This was followed by sounds like the firing of musketry, in quick succession, which ended with a rumbling noise like distant thunder, except that it continued with about the same degree of intensity until it ceased. It continued two or three minutes and seemed to come from the southwest, at an elevation above the horizon of 30 to 40 degrees, terminating in the

southeast, at about the same elevation. In the district where the meteorites fell, the explosions were heard immediately overhead.

The first reports were so heavy as to produce a tremulous motion, like heavy thunder, causing the glass in windows to rattle. The sound was so singular, that it caused some excitement and alarm, many supposing it an earthquake. At Barnesville, twenty miles east of Cambridge, the cry of fire was made, as the rumbling sound was thought to be the roaring of fire.

The day was cool and the sky covered at the time with light clouds. No thunder or lightning had been noticed that day; nor could any thing unusual be seen in the appearance of the clouds. Immediately on hearing the report, this observer looked in the direction it came, and noticed the clouds closely but could not see any thing unusual.

The next morning it was reported in Cambridge that aerolites had fallen on a farm in the vicinity of New Concord, (eight miles east, a little south of Cambridge), enquiries were immediately instituted, and Messrs. Noble and Hines state that they were near the house of a Mr. Amspoker at the time of the first explosion, which seemed directly over their heads. They looked up and saw two objects, apparently come through the clouds producing a twirling in the vapor of the cloud at the point, where they came through, then descending with great velocity and a whizzing sound to the earth—one striking about 300 yards to the southwest of them and the other about 100 yards north.

They immediately went to the spot where the first fell, and found it buried two feet in the ground. They dug it out and found it quite warm and of a sulphurous smell. The other struck a fence corner and breaking the ends of some of the rails penetrated into the earth sixteen or eighteen inches, passing through a heap of dry leaves; the first weighed 52 lbs., the other was broken up but must have weighed about 40 lbs. Another of 41 lbs. weight, not seen to fall, was discovered at the bottom of a hole two feet deep, where it had fallen on stiff turf, and was seen at the bottom of the hole, having carried the sod before it. It must have come from the southeast at an angle of 60° with the horizon. Many were discovered to have fallen southeast of Cambridge but of smaller dimensions than those already referred to. At the time of the occurrence nearly all were at dinner, or in and about their houses. The stones obtained were mostly found near houses, where they were seen to fall, as the sound of their striking the ground attracted attention.

Another well informed observer, Dr. McConnel of New Concord, (a small town eight miles east of Cambridge), furnishes the following particulars. On Tuesday, the 1st of May, at twenty-eight minutes past twelve o'clock, the people of that vicinity

were almost panic stricken by a strange and terrible report in the heavens, which shook the houses for many miles distant. The first report was immediately overhead, and after an interval of a few seconds, was followed by similar reports, with such increasing rapidity, that after the number of twenty-two were counted, they were no longer distinct, but became continuous and died away like the roaring of distant thunder; the course of the reports being from the meridian to the southeast. In one instance, three men working in a field,—their self possession being measurably restored from the shock of the more terrible report from above,—had their attention attracted by a buzzing noise overhead and soon observed a large body descending, strike the earth at a distance of about one hundred yards. Repairing thither they found a newly made hole in the ground, from which they extracted an irregular quadrangular stone weighing fifty-one pounds. This stone had buried itself two feet beneath the surface and when obtained was quite warm.

To this we add the following statement: "We the undersigned do hereby certify; that at about half past twelve o'clock on Tuesday, May the 1st, 1860, a most terrible report was heard immediately overhead, filling the neighborhood with awe. After an interval of a few seconds a series of successive reports, the most wonderful and unearthly ever before heard by us took place, taking a direction from meridian to southeast, where the sounds died away like the roaring of distant thunder, jarring the houses for many miles distant."

Signed by A. G. Gault, Jas. McDonnald, Nancy Mills, Ichabod Grumman, Samuel Harper, Rev. Jas. C. Murch, Mrs. M. Speer, Ang'e McKinney.

The above is from those who heard the noises but did not see the fall; the following are a few statements of the many I collected from those who witnessed the fall of the stones. I extract from their depositions made at the time.

"I heard the reports and roaring as above described. And a few seconds afterwards, I saw a large body or substance descending and strike the earth four or five hundred yards from where I then stood: and that I in company with Andrew Lister, repaired to the spot and about eighteen inches beneath the surface found a stone weighing fifty pounds." Signed by Samuel Reblu.

"Heard the reports and roaring as above described: and the said Mrs. Fillis further says, that a few seconds afterwards she heard a descending buzzing noise as of a body falling to the ground. And Miss Cherry also says that she was standing near Mrs. Fillis, heard the same and saw some substance descend and strike the earth some one hundred yards distant and that Mrs. Fillis repaired to the spot and there found a stone eighteen inches

beneath the surface weighing twenty-three pounds." Signed by Agnes Fillis, Mary J. Cherry.

"I distinctly heard the roaring and sounds as above described and a few seconds after the above report, I saw descending from the clouds a large body that struck the earth about one hundred and fifty yards from where I then stood, and I immediately repaired to the spot and about two feet beneath the surface found a stone weighing forty-two pounds, a second or two after seeing the first stone, I saw another descend and strike the earth about the same distance from where I stood, I also took the last mentioned stone from the earth about two feet beneath the surface; both the above stones when taken from the earth were quite warm. I also saw a third stone descend." Signed by Samuel M. Noble.

One observer saw a stone fall within three feet of his horse's head. One of the most southerly stones struck a barn; while some people retired within doors for fear of being struck.

These, with many others of a similar nature, were the data obtained near the region of the fall of stones. It is important to remember, that to these near observers no luminosity or fire ball was visible.

In addition to the above facts collected by ourselves, we have the following from observers at more distant points as already published by Profs. Andrews and Evans.

From the data they have collected, they consider the area over which the explosion was heard, as probably not less than one hundred and fifty miles in diameter. "At Marietta, Ohio, the sound came from a point north or a little east of north. The direction of the sound varied with the locality. An examination of all the different directions leads to the conclusion that the central point from which the sound emanated, was near the southern part of Noble county, Ohio," its course being "over the eastern end of Washington county, then across the interior of Noble county, then over the southwestern corner of Guernsey and the northeastern corner of Muskingum, with a direction of about 42° west of north."

"Mr. D. Mackley of Jackson county states that he was standing on the platform at the railroad station in Berlin, 20 miles south of Parkersburg, when he saw in a northeast direction, a ball of fire about 30° above the horizon. It was flying in a northerly direction with great velocity. It appeared as white as melted iron, and left a bright streak of fire behind it, which soon faded into a white vapor. This remained more than a minute, when it became crooked and disappeared."

Mr. Wm. C. Welles of Parkersburg, Virginia, (lat $39^{\circ} 10'$, long. $81^{\circ} 24'$), about sixty miles south of Cambridge, saw the meteorite as a ball of fire of great brilliancy emerging from be-

hind one cloud and disappearing behind another. Other observers at some distance to the south of the point where the fall occurred saw this meteorite as a luminous body.

The above I conceive to be all the observations worthy of note concerning the fall of this meteorite.

The time of the day, and the number and intelligence of the observers, unite to give considerable interest and value to these observations. While some of them show points of difference, natural to the observation of sudden and startling phenomena, we can yet deduce from them many conclusions with more or less accuracy, thus:—

The direction of the Meteorite.—My own observations of two of the stones which fell half a mile apart, enable me to give the direction of the meteor with some degree of exactness. The first of these stones struck the end of the rails of a Virginia (zig-zag) fence, half way down, just touching the middle rail, breaking off more and more of each rail as it passed to the ground. Connecting the points of fracture by a line, this line represents a descending curve from S.E. to N.W.

Again, the stone that fell at Law's (the most northerly), struck a large dead tree laying on the side of a hill, sloping N.W., passing through it as any projectile would; it then struck a small clump of elders, breaking them off at the root, falling finally at the foot of the hill. A line connecting these points shows the curve already stated. Coupling with this the observation of Mr. Callahan, on the direction that one of these stones penetrated the ground, with the observed path of their distribution, no doubt can remain that the general direction of their fall was from S.E. to N.W., striking the ground at an angle of about 60° .

Altitude of the Meteorite.—This is a point that can be determined but very imperfectly if at all. It may have been when first seen 40 miles above the earth, but when the explosion was heard it must have been nearer and was even still nearer when it subdivided and was scattered ('exploded' as usually termed,) over Guernsey and the edge of Muskingum counties. It is, however, but proper that I should give Prof. Evans's computation from the data he collected; they were published in the July number of this Journal, but their reproduction will not be out of place here.

"Mr. William C. Welles of Parkersburg, Virginia (lat. $39^{\circ} 10'$, long. $81^{\circ} 24'$), a gentleman of liberal education, testifies that being about three miles east of that place at the time of the occurrence, he happened to look up to the northeast of him, and saw a meteor of great size and brilliancy, emerging from behind one cloud and disappearing behind another. When about 35° east of north he thinks its altitude was 65° . Now the distance, in a direction 35° east of north, from his station to the line directly under the meteor's path, is 20 miles. Calculating from

these data I find for the vertical height, taken to the nearest unit, 43 miles. This was at a point in Washington county near the border of Noble.

"Mr. C. Hackley testifies that he saw the meteor from Berlin in Jackson county. It crossed a cloudless space in the northeast, and he thinks its altitude, at the highest point, was 30° . Now the distance from Berlin to the nearest point under the meteor's path is 70 miles. These data give nearly 41 miles for its vertical height over Noble county, a few miles to the south of Sarahsville (lat. $39^{\circ} 53'$, long. $81^{\circ} 40'$).

"Many other reliable witnesses have been found who saw the meteor through openings in the clouds from various points west of its path; and whose testimony so far agrees with the foregoing as to give results ranging between 37 and 44 miles. Care has been taken as far as possible to verify the data in each case by personal examination of the witnesses. The angles have in most instances been taken as pointed out by them from their respective posts of observation. It is unfortunate that no case has come to our knowledge in which the meteor was seen from the region east of its path. But it was a circumstance in some respects favorable to the definiteness of the observations made from the west side, that the observers in nearly all cases saw the meteor only at one point, or within a very small space on the heavens. It is impossible to reconcile the various accounts without granting that its path was very nearly as above described, and that its height did not vary far from 40 miles as it crossed Noble county.

"In regard to the time which intervened, at different places, between seeing the fire-ball and hearing the report, the statements are so vague that not much reliance has been placed upon them. It may be remarked, however, that they will essentially agree with the foregoing conclusions, if we suppose that the loudest explosion took place in the southern part of Noble county.

"I will add under this head the statement of Mr. Joel Richardson, of Warren, Washington county, who from a place six miles west of Marietta, saw the meteor as much as 15° or 20° west of north, at an altitude of about 45° . The direction in this case was so oblique to the meteor's path, that the data are of little value for simply determining the height; but they are important on account of their connection with the place of the meteor's last appearance. Mr. Richardson was visited by the writer, and his testimony was subjected to close scrutiny. If we take the azimuth at 15° west of north, we shall have a distance of 41 miles to the line under the meteor's path; and these data will give about 41 miles for its vertical height over a point not more than a mile from New Concord, at the extreme western limit of the district along which the meteorites were scattered. If we take the azimuth at 20° west of north, both the distance and the

height will be greatly augmented. I have found two persons living near Bear Creek, nine miles north of Marietta, who make statements closely corroborating that of Mr. Richardson.

"D. Mackley, Esq., a lawyer of Jackson, Ohio, who at the time of the occurrence happened to be at Berlin, about six miles northeast from the former place, and seventy miles from the nearest point under the meteor's path. He took pains to note all the facts as accurately as he could at that time; and he afterwards returned to the spot in order to determine more definitely the points of the compass. His testimony, in answer to my interrogatories is substantially as follows:—

"The meteor first appeared to me at a point about 55° east of north. It moved northward in a line very nearly parallel with the horizon. When it disappeared it had described an arc of about 15° . It was in sight about 6 seconds. Its altitude was about 30° . In regard to its size, I have since looked at the sun through a thin cloud, and I think the apparent diameter of the meteor was one-half that of the sun."

"These data give the meteor a height of 41 miles over the northern boundary of Noble county; a diameter of three-eighths of a mile; and a relative velocity of nearly four miles a second. The results agree sufficiently well with those before given."

Temperature of the Stones.—Several of the largest stones were picked up ten minutes after their fall, and are described as being about as warm as a stone that had lain in the sun in summer. One fell among dry leaves that covered it after it had penetrated the ground; the leaves, however, showed no evidence of having been heated; no appearance of ignition was discovered in places or objects with which the stones came in contact at the time of their fall; so that their temperature must have fallen far short of redness, while it may not have reached that of 200° .

Size and Velocity.—I have no data upon which to calculate either of these. Prof. Evans, however, as just quoted, calculates from the data above given, that its size was $\frac{2}{3}$ of a mile and velocity four miles a second.

While I may furnish no more reliable computations from the data obtained, I may be excused a short criticism on the above results to prevent too hasty conclusions being formed.

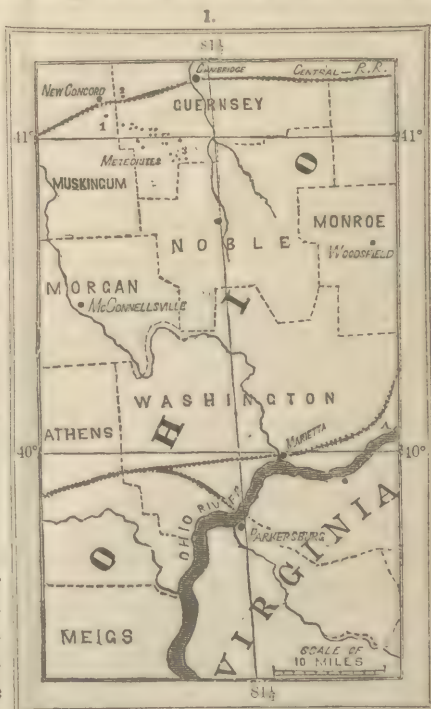
As regards the supposed elevation of forty miles *when the first reports were heard*, I would simply ask the question, is it possible, with the established views of the conduction of sound by rarefied air that any conceivable noise produced by a meteorite forty miles distant from the earth, in a medium quite as rare if not rarer than the best air pump can produce, would reach us at all, or if so, in the manner described by observers? This question is a more important one to consider; as some observers on similar data have calculated the elevation of meteorites, where they were first heard to explode, at one hundred miles.

As regards the size of the meteorite, I have but to refer the reader to my experiments made in 1854, and published in this Journal in 1855,* to show the perfect fallacy of calculating the size of luminous objects by their apparent disks, and I shall have more to say on the same subject in a future paper. It is important to note that the nearest approach of the meteor to the earth must have been in the northern part of Noble and in Guernsey counties, the point from which its most wonderful display seemed to have manifested itself; yet we hear nothing of its future career by reports from observers north of this, while its approach from the south to this point was noticed by a number of observers.

I need hardly state my own convictions are, that the meteorite terminated its career in Guernsey county, and that the group of stones which constituted it were scattered broad cast over that county: many have been collected, and many lie buried in the soil to moulder and mingle their elements with those of this earth.

We come now to consider the stones that fell and were collected. Their number was over thirty, and their places of falling have been plotted with some care in the accompanying map.

The localities of twenty-four have been fixed with precision, by the assistance of the Hon. C. J. Albright; but from the diminished scale of the map, it is impossible to place a number by each dot intended to represent the locality of a meteoric stone. No. 1 on the map is the spot where the largest stone was found, weighing 103 lbs. No. 2 is the next largest, weighing 56 lbs., and No. 3, the smallest, weighing 8 oz. The largest were at the northwest extremity, and smallest, at the southeast, the space over which they were scattered, was about ten miles long by three miles broad.



* Vol. xix, 340.

The following is a catalogue of 24:

No.	Weight.	Fell on farm of
1	103 lbs.	Shenholt.
2	56 "	Law.
3	52 "	Amspoker.
4	50 "	Amspoker.
5	41 "	Torrence.
6	36 "	Reasoner.
7	23½ "	Hodges.
8	26 "	Fillis.
9	16 "	Adair.
10	15 "	Craig.
11	8½ "	Craig.
12	4½ "	Waller.
13	4 "	Beresford.
14	3¾ "	Craig.
15	3¾ "	Stevens.
16	3¾ "	Wall.
17	3 "	Walker.
18	2¾ "	Claysville.
19	2 "	Stevens.
20	2 "	Wall.
21	2 "	Savely.
22	1 "	Carter.
23	1 "	Heskett.
24	½ "	Heskett.

Others have been found but I have no correct record of their exact position.

Some fifteen of these stones have come under my observation; they are all irregular in shape, cuboidal, wedge-shaped, globular and every conceivable form that irregular fragments of stone may be supposed to possess; they all have the well-known black coating with a sharp outline between the coating and grey mass of the stone, and there is quite a uniformity in the character of the coating in both small and large stones.

When broken this meteor exhibits a grey mass, with metallic particles of nickeliferous iron,* resembling the stones I examined that fell in Harrison county, Indiana, on the 28th of March, 1859, the latter however is the coarser grained of the two. Prof. Shepard who is familiar with the meteoric stones preserved in the cabinets of this country and in Europe, says: "In its internal aspect it approaches the stone of Iekaterinoslaw, Russia, (1825), though it is somewhat finer and more compact. In crust the two are identical. It is also similar to the stone Slobodka, Russia, (Aug. 10th, 1818); and compares closely with those of Politz, (Oct. 13th, 1819), of Nanjemoy, Maryland, (Feb. 10th, 1828),

* I have picked out pieces of the iron weighing two grains, closely cemented to pyrites.

and of Kuleschowka, Russia, (March 12th, 1811), but the crust is less smooth on the Ohio stone than in that of the latter. In fact its character is, that of a large portion of the known meteoric stones."

The general thickness of the crust is about from $\frac{1}{30}$ to $\frac{1}{40}$ of an inch.

The following is the figure of the largest stone that has been found, now in the cabinet of Marietta College, and described by Prof. E. B. Andrews, (this Jour., July, 1860, page 104). We reproduce the figure from Prof. Andrews's article here cited.

2.



Several specimens have been examined, they all show the presence of the same minerals with a slight variation in their proportions as might be expected in a mass not homogeneous. Its composition is fairly represented as follows:—Specific gravity, 3·550, varying slightly in different specimens.*

In 100 parts, there are,—

Nickeliferous iron,	- - - - -	10·7
Earthy minerals,	- - - - -	89·3

The nickeliferous particles separated by a magnet from the crushed stone and well washed, presented the following constituents in 100 parts.

Iron,	- - - - -	87·011
Nickel,	- - - - -	12·360
Cobalt,	- - - - -	·421
Copper,	- - - minute quantity not estimated.	
Phosphorus,	- - - - -	·012
Sulphur,	- - - - -	1·080

* Mr. Johnson gives it as 3·5417, this Journal, [2], xxx, 111.

The sulphur comes from magnetic pyrites that the meteorite contains and that it is not easy to separate mechanically from the small particles of nickeliferous iron.

The earthy part when freed as thoroughly as possible from nickeliferous iron (which can be done pretty effectually by the magnet), was treated with warm dilute muriatic acid, thrown on a filter first washed thoroughly with water, then with a solution of potash to dissolve the last portion of the silica of the decomposed portion of the mineral. The result was in 100 parts:

Soluble portion,	- - - - -	63.7
Insoluble "	- - - - -	36.3

The earthy material analyzed as a whole was found to contain,

Silica,	- - - - -	47.30
Oxyd of iron,	- - - - -	28.03
Alumina,	- - - - -	0.31
Magnesia,	- - - - -	24.53
Lime,	- - - - -	.02
Soda,	- - - - -	} 1.04
Potash,	- - - - -	
Manganese,	- - - - -	trace.

From these results it is very clear that the mineralogical constitution of these meteoric stones is about as follows in 100 parts.

Nickeliferous iron,	- - - - -	10.690
Schreibersite,	- - - - -	.005
Magnetic pyrites,	- - - - -	.005
Olivine,	- - - - -	56.884
Pyroxene,	- - - - -	32.416

This sums up the history of this meteoric shower, with as full an account as possible of the stones that fell at that time. In the first part of this paper it was stated that this fall was quite as remarkable as that near L'Aigle in France in 1803. Although it does not equal this latter in the number of stones that were collected, it exceeds it in the size of the stones that fell. The largest of the L'Aigle stones weighed $17\frac{1}{2}$ lbs., while the largest in the present case was 103 lbs.

There are many points of coincidence in the phenomena and circumstances attending the two falls. Were I to copy Biot's description of the phenomena of the fall at L'Aigle as detailed to the Academy of Sciences nearly sixty years ago, it would be but a repetition of what has been written in the first part of this paper.

The date of fall at L'Aigle was the 26th of April, the date of the Guernsey fall, May 1st; time of the day of the former, one o'clock, of the latter, twenty minutes of one. The direction of both falls from southeast to northwest. The extent of surface covered by the first seven and a half miles wide by two and a half broad, by the latter, ten miles long by three wide. And both were seen by a large number of persons.

Since my memoir on meteorites was presented to the American Association for the Advancement of Science, and published, I have collected several important physical and chemical data that cannot be overlooked in the study of the nature and origin of these bodies. I will merely enumerate some of them now; reserving for a future occasion the proof upon which they are based and the deductions that may be drawn from them. 1st. The light emitted from meteoric stones does not arise from incandescence, but from electricity or some other cause. 2nd. That the noise attending their fall is not that arising from the explosion of a solid, but that it is by concussion of the atmosphere arising from the rapid motion of the body through it or in part due to electric discharge.

3d. That meteoric showers are not the results of fragments from the rupture of one solid body, but the separation of small and distinct aerolites that have entered our atmosphere in groups. 4th. That the black coating is not of atmospheric origin, but is already formed when these bodies enter our atmosphere.

I would also call the attention of those engaged in the examination of this class of bodies to the study of the true nature of their black coating, also to the fact that observers at a distance often see these bodies in a luminous state, while those situated where they fall, do not observe this luminosity.

March 11, 1861.

